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ORIGINAL RESEARCH

In vitro Evaluation of Microleakage under Ceramic and Metal Brackets Bonded with LED and Plasma Arc Curing

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ABSTRACT

Aim: The aim of the present study was to evaluate these two high intensity light curing units regarding microleakage beneath metal and ceramic brackets.

Materials and methods: A total of 60 freshly extracted human premolar teeth were randomly divided into four groups of 15 samples; group I: Metal bracket + LED cured, group II: Ceramic bracket + LED cured, group III: Metal bracket + plasma arc cured, group IV: Ceramic bracket + plasma arc cured.

After photopolymerization, the teeth were immersed in water and thermocycled (500 cycles between 5 and 55). Specimens were further sealed with nail varnish and stained with 5% basic fuchsin for 24 hours. All of the teeth were sectioned with two parallel longitudinal occlusogingival cuts and examined under a stereomicroscope. The microleakage was measured with a digital caliper and scored from 0 to 3 for marginal microleakage at the bracket-adhesive and adhesive-enamel interfaces from both the occlusal and gingival margins.

Results: Microleakage was detected in all groups. The plasma arc cured group showed less microleakage than light emitting diode (LED) cured in all samples at the enamel-adhesive interface at the gingival margin (ceramic brackets, $p = 0.009$ and metal brackets, $p = 0.005$). The plasma arc cured samples showed less microleakage than LED cured in metal brackets at the adhesive-brackets interface at the occlusal margin ($p = 0.033$). While curing with an LED unit, ceramic brackets displayed significantly less microleakage than metal ones at the gingival margin of adhesive-enamel interface ($p = 0.013$).

The gingival margin in all groups exhibited higher microleakage compared with those observed in occlusal sides in all sample groups ($p < 0.001$).

Conclusion

1. LED units cause more microleakage than plasma arc units.
2. In all groups the microleakage at the gingival margin is greater than the occlusal margin.

Clinical significance: The microleakage formation permits the passage of bacteria and oral fluids initiating white spot lesions beneath the bracket base.

Keywords: Microleakage, LED unit, Plasma arc unit, Metal bracket, Ceramic bracket.

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INTRODUCTION

Nowadays, various commercial light curing adhesives are used in orthodontics for bonding brackets. Many efforts have been done to introduce a trustworthy adhesive for orthodontic attachments on enamel surface. Appropriate primary bond strength and durability are considered as ideal adhesive characteristics. The most important drawback of these adhesives is that they contract during polymerization, resulting in marginal gaps and microleakage.[1] Contraction during polymerization causes mechanical stress within the resin composite and destruction of the marginal seal between composite and enamel.[2] The presence of microspaces between the adhesive and enamel surface leads to bacteria and saliva penetrance that can cause decalcification and even formation of white spots beneath and around the brackets. The resulting unsightly appearance of white spot lesions results in patient dissatisfaction.[1,3] Due to the working time at hand for precise bracket positioning light cured adhesive resins has attracted a great attention in today's orthodontic treatment. The most commonly used unit for the purpose is the QTH (Quartz-Tungsten-Halogen) light unit,[4] wherein a halogen lamp emits light and the filter allows passage of pure blue light. The main disadvantage of this unit is the short life span of the halogen bulbs (40-100 hours) and the heat produced by them causing reduction of the quality of the lamp, reflector and filter function. It has also been shown that the output of the light curing unit (LCU) halogens is not the same as declared by the companies.[3,5] Nowadays, high intensity light sources, such as plasma arc cutting (PAC) and light emitting diodes (LED) have been introduced. In the plasma arc unit, light is emitted from a gas composed of ionized molecules (plasma). Since the intensity of light is high in PAC, the curing time and consequently the chair time is reduced. It has been showed that polymerization with high intensity light has lesser chance of releasing stress in the resin bond used for reconstructions. The production companies claim that the polymerization time is reduced to 3 to 10 seconds, minimizing the polymerization contraction.[6]

Although a short time has passed from the introduction of LED, they are being used widely. A semiconductor is used for production of light in these units. Their minimum life span is 1000 hours and there is no need for halogen lamps. Their emission does not decrease with time and additionally they are rechargeable and are portable.[4] Due to the increasing enthusiasm for adult orthodontics and the demand for more esthetic attachments, the ceramic brackets have overwhelmingly got attention in orthodontic field.

The studies examining the rate of microleakage beneath the bracket bases have reported microleakage to be present in all of the groups.[7-10] There has been reported more bracket– adhesive microleakage in metal brackets compared to ceramic brackets.[7,8] Ceramic brackets cured with LED have shown lesser rate of microleakage as compared to QTH cured.[7] The results of certain studies have shown that the microleakage on the gingival margin is much more significant than the amount on the occlusal margin.[9]

Ulker et al studied the microleakage of the enamel-adhesive-bracket complex in metal brackets cured with ordinary and high intensity light. They showed that high intensity light does not cause more microleakage than ordinary light and advocated their routine use.[10]

There has been no study to date comparing the LED and PAC with respect to the rate of microleakage beneath metal and ceramic brackets. The aim of the present study was to evaluate these two high intensity LCUs regarding microleakage beneath metal and ceramic brackets.

MATERIALS AND METHODS

This study was a descriptive, experimental and laboratory trial study done with the parallel plan. A total of 60 human premolar teeth—removed for orthodontic purpose—were selected. All the samples were healthy and without cracks. They were stored at room temperature in distilled water and the water was changed daily. The teeth removed just prior to bonding of the brackets and cleaned with a scaler, pumice powder and a handpiece so as to remove any soft tissue, plaque or stains from the teeth. They were divided into four groups of 15 teeth. The buccal surfaces of all the teeth were etched with 37% phosphoric acid gel for a period of 30 seconds, then washed with water for 30 seconds and dried with an air blower. After etching, adhesive (ortho-technology resilience) was applied to the teeth and cured. The four groups were bonded with the adhesive as follows:

- *Group I: Metal brackets:* Standard edgewise, 0.018 × 0.025 slots (Dentaurum)-were bonded on the teeth and cured with LED (Top light Taiwan). The intensity of the unit light was measured before curing with a radiometer to be 680 mw/cm^2 for a period of 20 seconds, 5 seconds for each side of the bracket base.
- *Group II: Ceramic brackets:* Standard edgewise, 0.018 × 0.025 slots (Dentaurum)-were bonded to the teeth and cured with LED as explained above.
- *Group III:* Metal brackets were bonded to the teeth and cured with plasma arc (Dentamerica USA Litex 685) with intensity of 1300 mw/cm^2 for a period of 12 seconds, 3 seconds per each surface area.
- *Group IV:* Ceramic brackets were bonded to the teeth and cured with plasma arc just as group III.

The light exposure time in each light machine was divided by four and all surfaces (occlusal, gingival, mesial and distal) of the bracket bases were exposed equally to create near ideal conditions for curing.[11] Then they were exposed to 5 to 55º thermal cycle for a 500 cycles.

Then, the apices of all the teeth were sealed with wax gum. All the samples were brushed with nail polish except 1 mm boundary around the brackets (Fig. 1). The teeth were immersed for 24 hours in 0.5% fusion solution (Ghatran Co) at room temperature. The 0.5% fusion solution was prepared by dissolving 1 gram fusion powder in 200 ml of distilled water. The teeth were removed from the solution after 24 hours, washed with water and the surface color was removed by a toothbrush. The teeth were then dried and placed in acrylic resin blocks (Fig. 2). With the use of a special disk and cutting machine, two longitudinal

Fig. 1: All the samples were brushed with nail polish except 1 mm boundary around the brackets

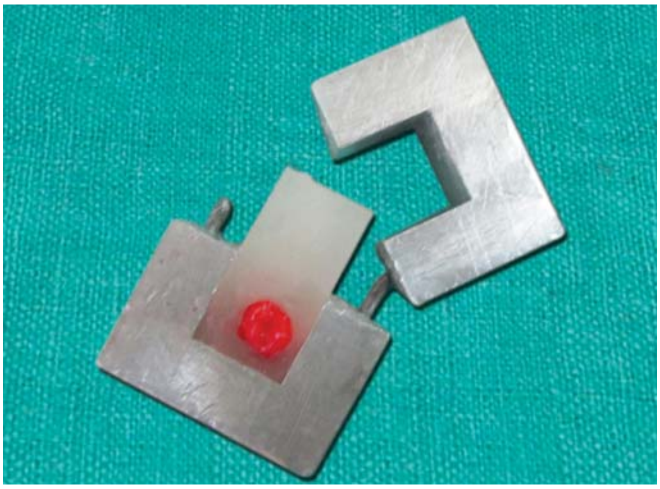

Fig. 2: The teeth were then dried and placed in acrylic resin blocks

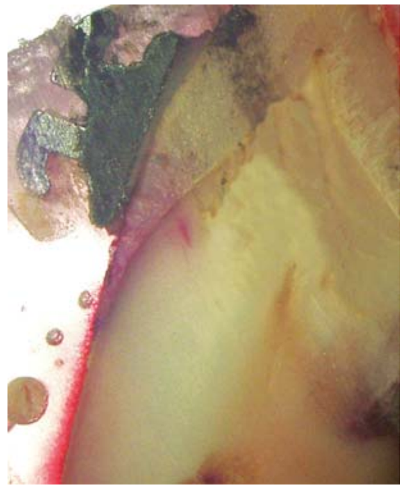

Fig. 4: The maximum color penetration of 3 mm (group III)

buccolingual cuts were done, at the mesial and distal side of the brackets. From the four surfaces of each tooth, three surfaces with the least cutting damage were selected and examined under a stereomicroscope (ztx-3E) with a magnification power of ×20. In this way, a total of 180 specimens were obtained. A trained individual examined the rate of microleakage of the samples that was in the form of penetration of the fusion color in each sample. A digital kulis was used to measure four locations; occlusal and gingival sides of the bracket–adhesive and occlusal and gingival aspects of the adhesive-enamel junction. The data was classified into four groups as follows and the Kruskal-Wallis and Mann-Whitney tests were adopted for statistical analysis.

- *Group 0:* No bracket-adhesive or adhesive-enamel color penetration (Fig. 3).
- *Group I:* The maximum color penetration of 1 mm.
- *Group II:* The maximum color penetration of 2 mm.
- *Group III:* The maximum color penetration of 3 mm (Fig. 4).

Fig. 3: No bracket-adhesive or adhesive-enamel color penetration (group 0)

RESULTS

The mean microleakage in the various groups on the basis of the type of bracket and curing method is shown in Table 1. According to the results, in the LED method, there was a significant difference between the adhesive-bracket microleakage in the occlusal region of the metal and ceramic brackets ($p = 0.013$), but this difference was not significant in the plasma arc method ($p = 1$). Similarly, the adhesive-bracket microleakage in the occlusal region of the metal brackets was significantly different in the LED and plasma arc methods ($p = 0.033$), but this difference was not significant in the case of ceramic brackets ($p = 0.723$).

There was no significant difference between the adhesive-bracket microleakage in the gingival region of the metal and ceramic brackets in the LED and plasma arc methods.

Similarly, there was no significant difference between the adhesive-enamel microleakage in the occlusal region of the metal and ceramic brackets in the LED and plasma arc methods. Though the rate of microleakage in the ceramic brackets cured by the plasma arc method was lower than the metal brackets, the difference was not significant.

The rate of adhesive-enamel microleakage in the gingival region of the metal brackets ($p = 0.005$) and ceramic brackets ($p = 0.009$) cured with both the plasma arc and LED methods was significantly different from that of the plasma arc as compared to the LED.

Also, there was a significant less bracket-adhesive-enamel microleakage in the occlusal region of the ceramic barackets as compared to metal ones cured by the LED method ($p = 0.033$). The amount of microleakage was also less in the ceramic brackets as compared to the metal brackets cured by the plasma arc method, but the difference was not significant.

The difference in the rates of microleakage of the bracket-adhesive-enamel group in the gingival region of the metal (p = 0.022) and ceramic brackets (p = 0.05) cured by the LED and plasma arc methods was statistically significant; the rate of microleakage in the plasma arc method was less than that of LED. But there was no significant difference between the rates of bracket-adhesive-enamel microleakage in the gingival margin of the ceramic and metal brackets cured by two methods.

The rate of microleakage in the occlusal and gingival margins were significantly different and was higher in the gingival portion (p = 0.001, Table 2).

Curing with the plasma arc unit resulted in lesser amount of microleakage in both metal and ceramic brackets (p = 0.025, Table 3).

DISCUSSION

The potential of white spots formation is a specific problem related to orthodontic brackets bonding. Demineralization of the enamel and the resulting white spots can advance during orthodontic treatment.[7] Polymerization shrinkage that occurs in the bonding material can result in destruction of the marginal seal. The fine gaps formed between the enamel and composite result in microleakage under the bracket which can be a trigger point for enamel decalcification and formation of white spot lesions.[2,12]

There are many methods for studying microleakages, the most commonly used is color penetration.[13]

According to the results of the present study, the enamel-adhesive microleakage in the gingival region of both ceramic and metal brackets was significantly lower in the plasma arc group as compared to the LED group. Similarly, the adhesive-bracket microleakage in the occlusal portion of the metal brackets in the plasma arc group was significantly lower than that of the LED group.

There are not great studies comparing the microleakages of different types of brackets, curing and bonding methods. In a study by Ulker et al,[10] they concluded that adhesive curing method has no effect on the rate of microleakage in the occlusal and gingival region of the samples. Their result was not in line with the results of the present study. The reasons for this difference can be related to different power sets and different curing patterns. Ulker et al[10] used the PAC with a power of 1500 mw/cm^2 for a period of 6 seconds from only one side of the bracket bases, while in the present study plasma arc with a power of 1300 mw/cm^2 for a period of 12 seconds was used on all four sides of the bracket bases (3 seconds/side). Decreased speed results in enough polymerization reaction time for visible molecular changes

Table 1: Comparison of the mean microleakage in various groups on the basis of type of bracket and method of curing

	Bracket / *Curing method*	*Metal brackets*			*Ceramic brackets*			*p-value*
		Median	*Mean*	*SD*	*Median*	*Mean*	*SD*	
OAB	LED	0	0.42	0.72	0	0.13	0.40	0.013
	Plasma arc	0	0.2	0.58	0	0.2	0.58	1
	p-value		0.033			0.723		
GAB	LED	0	0.33	0.71	0	0.33	0.52	0.549
	Plasma arc	0	0.31	0.67	0	0.35	0.65	1
	p-value		0.844			0.844		
OAE	LED	0	0.2	0.55	0	0.15	0.52	0.717
	Plasma arc	0	0.31	0.67	0	0.11	0.38	0.08
	p-value		0.3			0.727		
GAE	LED	1	0.67	0.74	0	0.62	0.75	0.732
	Plasma arc	0	0.31	0.7	0	0.24	0.43	0.798
	p-value		0.005			0.009		
OA	LED	0	0.48	0.66	0	0.22	0.47	0.033
	Plasma arc	0	0.35	0.57	0	0.24	0.48	0.33
	p-value		0.338			0.802		
GA	LED	1	0.69	0.59	1	0.67	0.56	0.897
	Plasma arc	0	0.42	0.62	0	0.44	0.54	0.657
	p-value		0.022			0.05		

- Mann-Whitney test
- Microleakage between adhesive and enamel in occlusal region—OAE
- Microleakage between bracket and adhesive in occlusal region—OAB
- Microleakage between adhesive and enamel in gingival region—GAE
- Microleakage between bracket and adhesive in gingival region—GAB

Table 2: Comparison of the mean microleakage in occlusal and gingival regions of all of the samples

	Mean	*SD*	*p-value*
Occlusal	0.26	0.35	<0.001
Gingival	0.136	0.31	

Mann-Whitney test

Table 3: Comparison of the mean microleakage in the group on the basis of type of curing

Type of curing	*Median*	*Mean*	*SD*	*p-value*
LED	1	0.75	0.52	0.025
Plasma arc	1	0.58	0.56	

Mann-Whitney test

and sealant thus possibly reduction in the stretch due to contraction during polymerization. Therefore, the adhesive is polymerized completely and microleakage is less. It is possible that in the Ulker et al[10] study higher power of light induced faster curing and less resin movement due to limited time for curing. This can lead an increase in adhesive contraction during polymerization, lay gap between the enamel and composite, and ultimately increase the amount of microleakage.[14] Another reason for the difference can be related to the thermocycling. In the Ulker et al[10] study thermocycling was not involved, while in the present study thermocycling at a rate of 500 cycles between 5 and 55º was performed. It has been reported that thermocycling causes reduction of bond strength[15,16] and or increase in microleakage.[15] Other studies have dismissed the relation between the number of thermal cycles and increased microleakage.[17,18] Considering the point that there is continuous thermal stress in the oral environment between the teeth surface and resin, *in vitro* thermal simulation using thermal cycles between 5 and 55º was used in the present study.[9] The adhesive material used in the present study was different from that of Ulker et al's[10] that could be the reason for the difference in the results of these two studies. The contraction of the adhesive during polymerization depends on the constituents of the adhesive.[9]

Due to the present study data, the mean value of microleakage at the gingival margin was significantly higher than the occlusal portion. This result confirms the results of the studies by Ulker et al,[10] Uysal et al[18] and Arhan et al,[8] but is in contrast to the result of Yagci et al.[19] This difference can be explained by first, the curvature on the gingival portion in comparison to the occlusal. This results in deposition of a thicker layer of adhesive on the gingival side thus increasing the chances of microleakage. Additionally, the direction of the enamel rods is different in the occlusal and gingival portions of buccal surface which can be the reason for the difference in microleakage in the two regions as the result of variable etching patterns. But the Uysal et al[9] and Ulker et al[10] studies had a different opinion and believed that the lower amount of microleakage in the occlusal region in comparison to the gingival border was due to method of light exposure; as the samples were litted from the occlusal side. As it is stated before in the the present study though the brackets were exposed equally from all sides (occlusal, gingival, mesial and distal), the microleakage on the occlusal border was less than that of the gingival border. According to the authors the direction of light exposure cannot be the reason for the increased microleakage on the gingival side. The most probable cause for the increased microleakage on the gingival margin could be the increased curvature of the dental surface on this portion that results in deposition of a thicker layer of adhesive there. This factor can cause an increase in contraction, polymerization and leakage. In contrast to reconstructive dentistry wherein cavities are filled with thick layer of resin composite, in orthodontics as only a thin layer of composite is applied beneath the brackets, contraction, polymerization and microleakage is also less.

Due to the present study, the ceramic brackets showed less amount of microleakage as compared to the metal brackets when cured with the LED unit that was in line with the results of the study by Arikan et al.[7] They studied the microleakage of ceramic and metal brackets cured with LED and QTH. Arikan et al[7] concluded that ceramic brackets cured with LED machines were the best combination and had the least microleakage in the bracket-adhesive and adhesive-enamel interface on both the occlusal and gingival sides.

Many studies have shown that ceramic brackets create stronger bonds as compared to metal brackets.[9] Arham et al[8] reported that the high bond strength (chemical bond) and difficulty in debonding the ceramic brackets results in absence of microleakage in these brackets. Uysal et al[9] concluded that incomplete adhesive polymerization beneath the metal brackets could be responsible for this difference.

CONCLUSION

In the present study as already mentioned, when LED machine was used for bonding the brackets, the rate of microleakage of the ceramic brackets was significantly lower than the metal ones. This was also the case when plasma arc was used instead of LED, but this difference was not significant. The reason for this could be the small sample size and a larger sample study could make this difference significant.

CLINICAL SIGNIFICANCE

The adhesives shrinkage during polymerization results in marginal gaps and eventually microleakage at the tooth-adhesive interface. The microleakage formation permits the passage of bacteria and oral fluids initiating white spot lesions beneath the bracket base.

Anyway, the authors conclude that the lower rate of microleakage in ceramic brackets could be due to the high bond strength of these brackets. The chemical bond of these brackets to the composite resin causes a stronger bond as compared to the metal brackets. This must be taken into consideration when bonding the brackets to the porcelain crowns.

REFERENCES

1. Eliades T, Eliades G, Brantley WA, Johnston WM. Polymerization efficiency of chemically cured and visible light-cared orthodontic adhesives: Degree of cure. Am J Orthod Dentofacial Orthop 1995;108:294-301.
2. Aquiar FH, Ajdavtek F, Lovadino JR. Effect of light modes and filling techniques on microleakage of posterior resin composite restoration. Oper Dent 2002;27(6):557-62.
3. Hofmann N, Hugo B, Schubert K, Klaiber B. Comparison between a plasma arc light source and conventional halogen curing photoactivated resin composites. Clin Oral Invest 2000;4: 140-47.
4. Mills RW, Jandt KD, Ashworth SH. Dental composite depth of cure with halogen and blue light emitting diode technology. Br Dent J 1999;186:388-91.
5. Ozer F, Unlu N, Karakaya S, Kusdemir M, Ulker M. Effect of light source intensity on shear bond strength. Abstract presented at the joint mitting of continental. European division (CED), scandinavian division (NOF) and Israili divisian (ID) of the international association for dental research (IADR), Aug 25-28, 2004 Istanbul, Turkey.
6. Jung H, Friedl KH, Hiller KA, Haller A, Schmalz G. Curing efficiency of different polymerization methods, through ceramic restoration. Clin Oral Invest 2001;5-156-61.
7. Arikan S, Arhun N, Arman A, Cehrel SB. Microleakage beneath ceramic and metal brackets photopolymerized with LED or conventional light curing units. Angle Orthod 2006;16(6): 1035-40.
8. Arhan N, Arman A, Cehreli SB, Arikan S, Karabulut E, Gulsahl K. Microleakage beneath ceramic and metal brackets bonded with a conventional and an antibacterial adhesive system. Angle Orthod 2006;76(6):1028-33.
9. Uysal T, Ulker M, Ramoglu SI, Ertas H. Microleakage under metallic and ceramic brackets bonded with orthodontic self-etching primer systems. Angle orthod 2008;18(6):1089-94.
10. Ulker M, Uysal T, Ramoglu SI, Ertas H. Microleakage under orthodontic brackets using high-intensity curing lights. Angle Orthod 2009;79:144-49.
11. Jung H, Friedl KH, Hiller KA, Haller A, Schmalz G. Curing efficiency of different polymerization methods, through ceramic restoration. Clin Oral Invest 2001;5:156-61.
12. James JW, Miller BH, English JD, Tadlock LP, Buschange PH. Effect of high speed caring devices shear bond strength and microleakage of orthodontic brackets. Am J Orthod 2003;123: 555-61.
13. Nilgun Ozturk A, Usimez A, Ozturk B, Usumes S. Influence of different light sources on microleakage of class V composit resin restorations. J Oral Rehabil 2004;31(5):500-04.
14. Mehl A, Hickel R, Kunzelmann KH. Physical properties and gap formation of light cured composits with and without soft start polymerization. J Dent 1997;25(3-4):321-30.
15. Sokucu O, Siso SH, Ozturk F, Nalcaci R. Shear bond strength of orthodontic brackets cured with different light sources under thermocycling. Eur J Dent 2010;4(3):257-62.
16. Elekdag-Turk S, Turk T, Isci D, Ozkalayci N. Thermocycling effects on shear bond strength of a self-etching primer. Angle Orthodontist 2008;75(2):351-60.
17. Ulker M, Özcan M, Sengün A, Özer F, Belli S. Effect of artificial aging regimens on the performance of self-etching adhesives. J Biomed Mater Res B: Appl Biomater 2010;93(1):175-84.
18. Bedran-de-Castro AK, Cardoso PE, Ambrosano GM, Pi-menta LA. Thermal and mechanical load cycling on micro leakage and shear bond strength to dentin. Oper Dent 2004;29:42-48.
19. Yagci A, Uysal T, Ulker M, Ramoglu SI. Microleakage under orthodontic brackets bonded with the custom base indirect bonding technique. Eur J Ortho 2009;117-23.

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